

Health Effects and Occurrence of Arsenic in Texas' Public Water Supplies

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Background

- ▶ Negative effects of arsenic have been known for a very long time
- ▶ The word “arsenic” is derived from the Greek “arsenikon” meaning potent
- ▶ As early as 2000 BC, the word has been synonymous with poison



Background (cont.)

- ▶ “The perfect poison” - odorless, nearly tasteless, hard to detect in the body
- ▶ Historically used for political assassinations
- ▶ Thought to be responsible for the deaths of: Claudius, Pope Pius III, Napoleon



Sources

- ▶ Agriculture - insecticides, rat poison, herbicides and wood preservative
- ▶ Pigments - paints, ceramics, wallpaper
- ▶ Medicine - treatment of syphilis, psoriasis
- ▶ Naturally occurring



Arsenic Health Effects

- ▶ By ingestion, dermal exposure is minimal
- ▶ Interferes with physiologic activities - actions of enzymes, essential cations, transcriptional events in cells
- ▶ Class A human carcinogen



Arsenic Health Effects

Chronic exposure to low levels (<0.05 mg/L) linked to:

- ▶ Cancers - bladder, lungs, skin, kidneys, nasal passages, liver and prostate
- ▶ Cardiovascular, pulmonary, immunological and neurological effects



Arsenic Occurrence and Spatial Distribution

Matt Court

Source Water Assessment & Protection Program



Arsenic Occurrence

- ▶ Arsenic occurs naturally in rocks and soil, water, air, and plants and animals.
- ▶ Concentrations in soil range from 0.1 to 40 mg/kg
- ▶ Highest concentrations in some igneous and sedimentary rocks
- ▶ Processes that release arsenic into the environment include: volcanic activity, erosion of rocks, and forest fires, or through human actions.



Arsenic Occurrence (cont.)

Human Actions Include:

- ▶ Approximately 90% of industrial arsenic in the U.S. is currently used as a wood preservative.
- ▶ Arsenic is also used in paints, dyes, metals, drugs, soaps, and semi-conductors.
- ▶ Agricultural applications, mining, and smelting also contribute to arsenic releases in the environment.
- ▶ Estimated 8 million lbs released into the environment in 1997

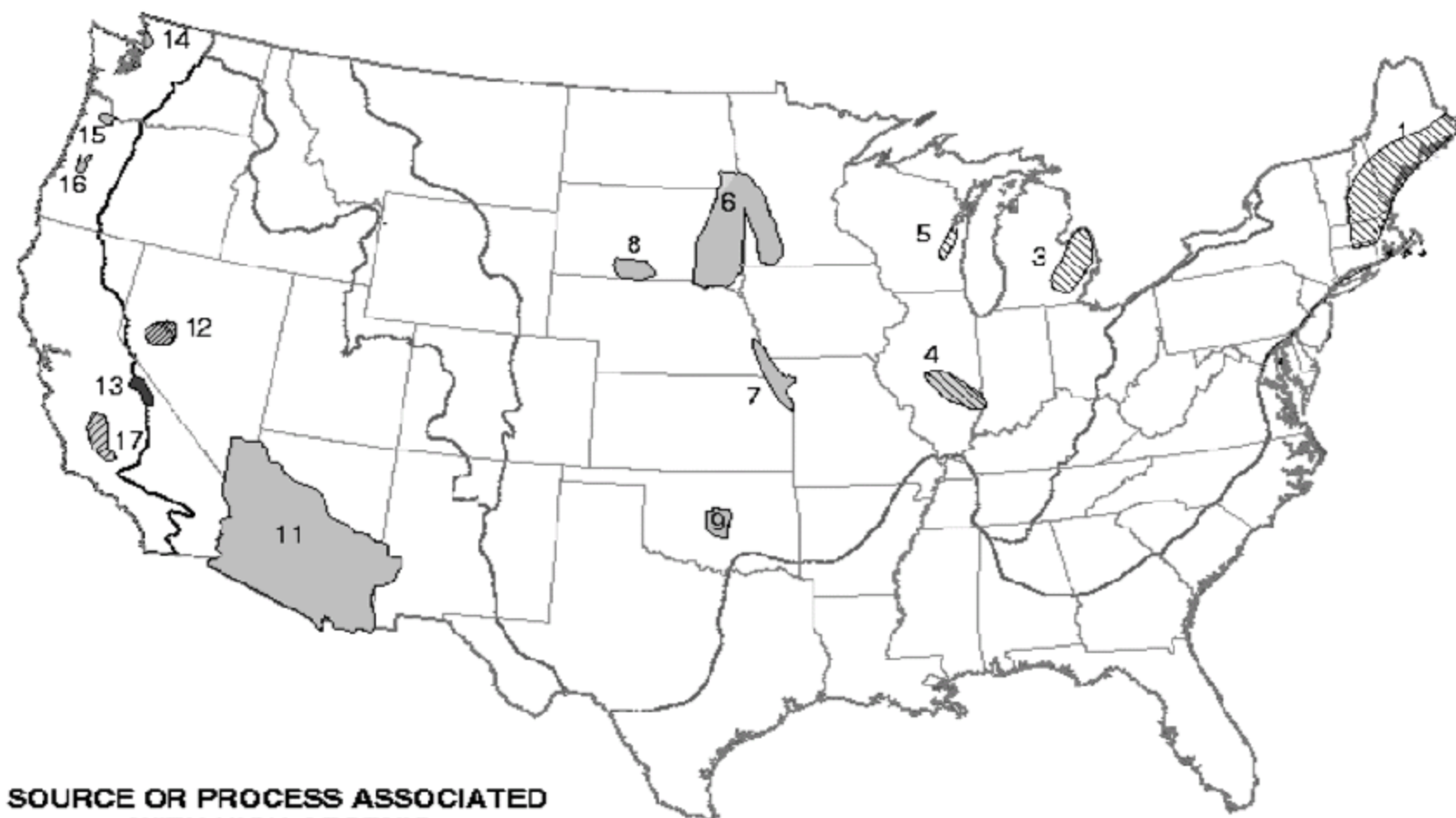


Arsenic Occurrence (cont.)





- ▶ Higher levels of arsenic tend to be found more in ground water sources than in surface water sources of drinking water.
- ▶ Generally, Western States have more systems with arsenic levels greater than 10 ppb.
- ▶ Parts of the Midwest and New England do have some systems with levels greater than 10 ppb, but more with levels that range from 2 -10 ppb.
- ▶ While many systems may not have detected arsenic greater than 10 ppb, there may be geographic “hot spots” with systems that have higher levels than the predicted occurrence for that area.



Sources or Processes Associated with Arsenic



**SOURCE OR PROCESS ASSOCIATED
WITH HIGH ARSENIC**

-  Thermal water
-  Fe-oxide
-  Sulfide minerals
-  Evapotranspiration

Arsenic Source Table

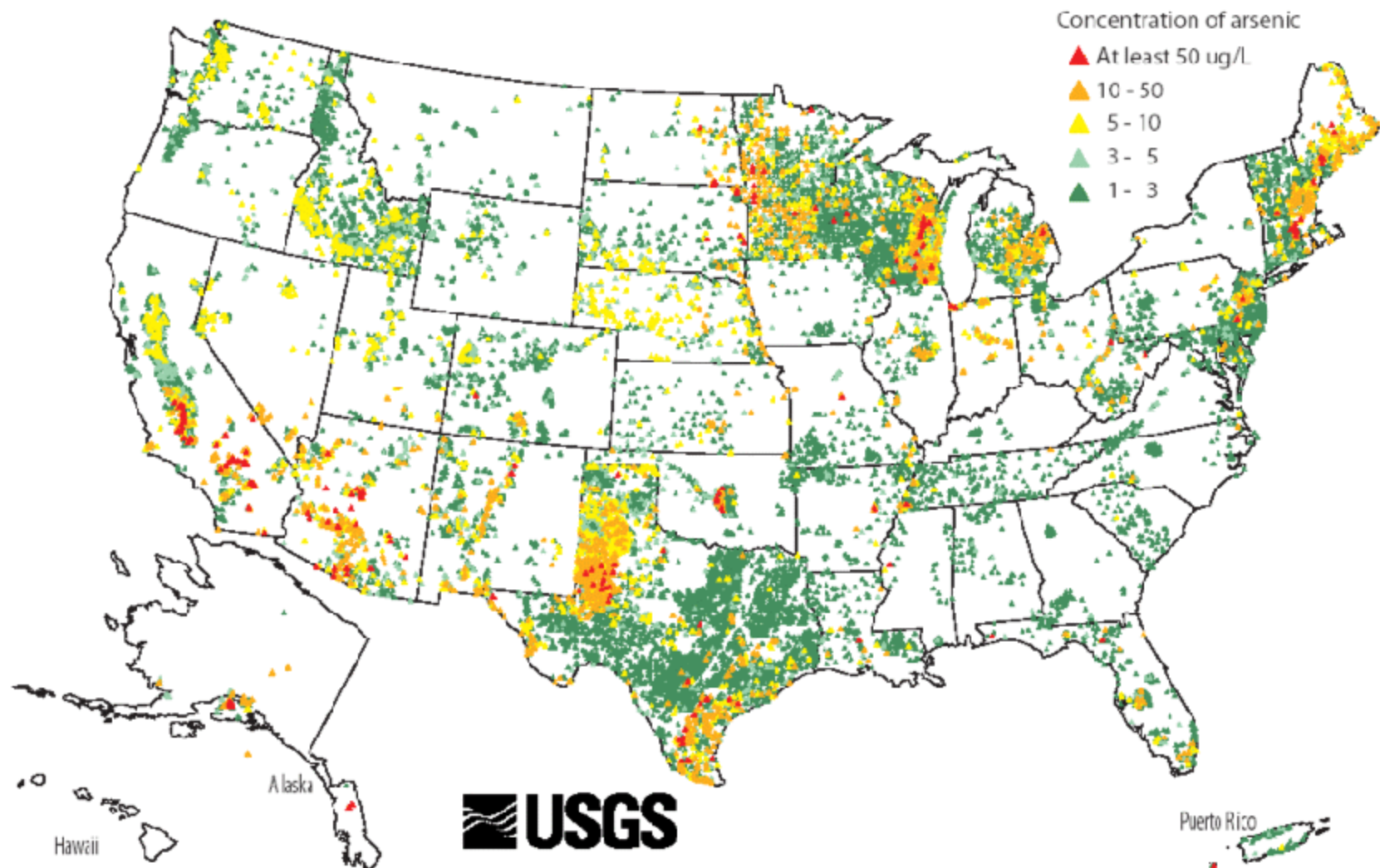
Table 1. Areas with high arsenic concentrations derived from natural sources

Source of arsenic ¹	Hydrologic units and number of area shown on <u>Figure 1</u>	References
Sulfide minerals and Fe-oxide	Bedrock (1) ²	Zuena and Keane, 1985; Boudette <i>et al.</i> , 1985; Marvinney <i>et al.</i> , 1994; Ayotte <i>et al.</i> , 1998; Peters <i>et al.</i> , 1998
Fe-oxide (D)	Paleozoic sandstone(2)	Matisoff <i>et al.</i> , 1982
Sulfide minerals	Glacial deposits, sandstone ³ and shale(3)	Westjohn <i>et al.</i> , 1998, Kolker <i>et al.</i> , 1998
Fe-oxide (D)	Glacio-fluvial deposits ⁴ (4)	Voelker, 1986; Holm and Curtiss, 1988; Parno <i>et al.</i> , 1994; Holm, 1995, Korte, 1995
Sulfide minerals	Ordovician carbonate and clastic rocks (5)	Simo <i>et al.</i> , 1996
Fe-oxide (D, P)	Glacial deposits and shale (6)	Roberts <i>et al.</i> , 1985; Kanivetsky, in press
Fe-oxide (D)	Alluvium (7)	Ziegler <i>et al.</i> , 1993; Korte, 1991
Fe-oxide (P)	Volcanic ash (8)	Carter <i>et al.</i> , 1998
Fe-oxide (P)	Sandstone and mudstone (9)	Schlottmann and Breit, 1992; Norvell, 1995
Black shale lithic fragments	Glacio-fluvial deposits	Yarling, 1992
Geothermal water	Volcanic rocks (10)	Stauffer and Thompson, 1984; Ball <i>et al.</i> , 1998
Fe-oxide (P)	Basin fill sediments, including volcanic, alluvial, and lacustrine deposits (11)	Owen-Joyce and Bell, 1983; Owen-Joyce, 1984; Robertson, 1989
Fe-oxide (D, P) and evaporative concentration	Basin fill sediments, including alluvial and lacustrine deposits (12)	Welch and Lico, 1998
Geothermal water	Volcanic rocks (13)	Mariner and Willey, 1976; Eccles, 1976; Wilkie and Hering, 1998
Fe-oxide ⁵ (P)	Alluvium (14)	Goldstein, 1988, Fickin <i>et al.</i> 1989; Davies <i>et al.</i> , 1991
Fe-oxide (D)	Basin-fill deposits (15)	Hinkle, 1997
Fe-oxide (P)	Felsic-volcanic tuff(16)	Goldblatt <i>et al.</i> , 1963, Nadakavukaren <i>et al.</i> , 1984
Fe-oxide and evaporative concentration	Basin-fill sediments, including alluvial and lacustrine deposits (17)	Fujii and Swain, 1995; Swartz, 1995; Swartz <i>et al.</i> , 1996

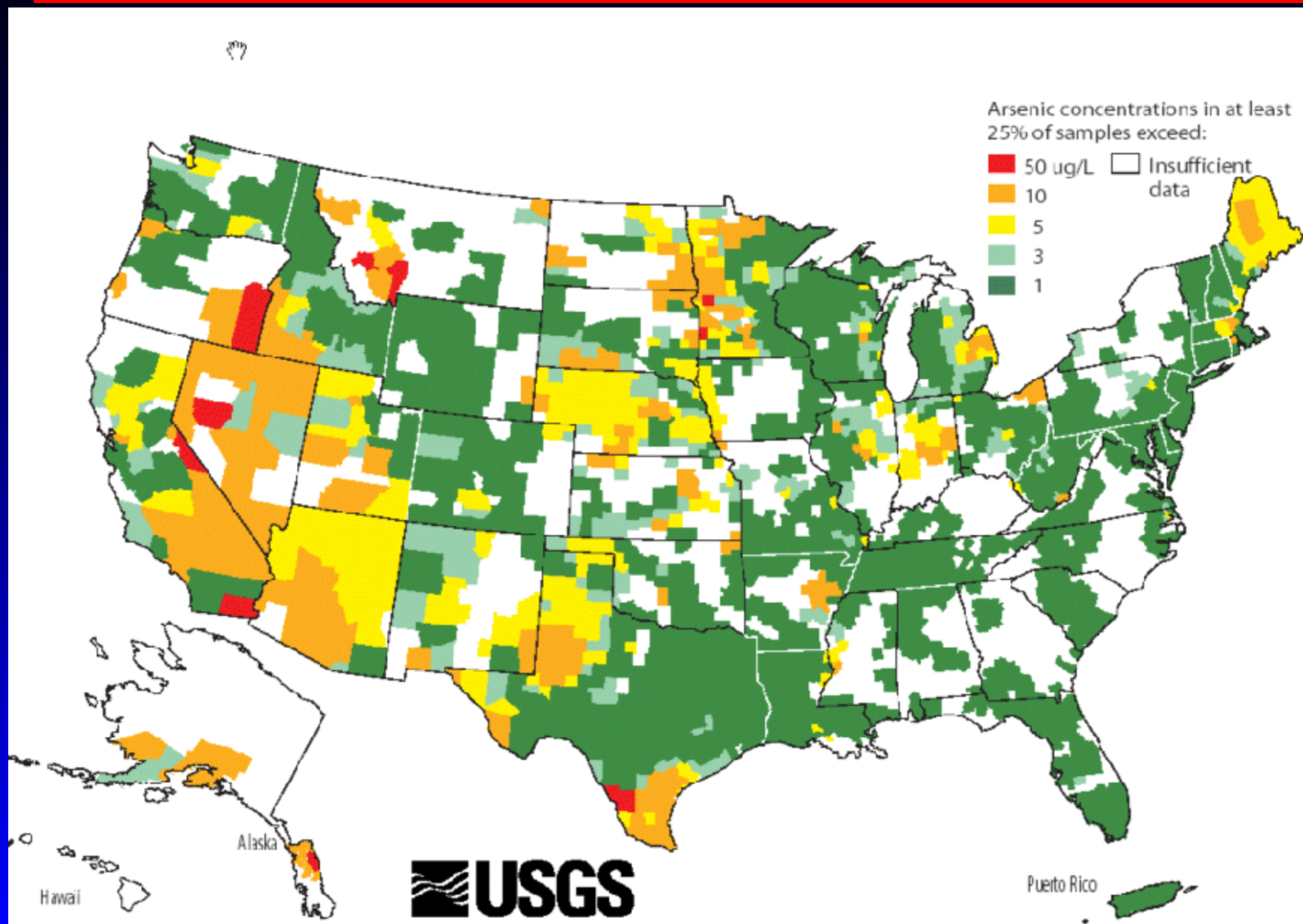
Arsenic Source Table -Footnotes

1. Known or inferred. For areas with Fe-oxide as a source of arsenic, dissolution of the oxide and desorption are important processes that can release arsenic to ground water. The letters 'D' and 'P' in parentheses refer to the processes of dissolution and pH-influenced desorption of arsenic, respectively.
2. Arsenic concentrations in ground water are generally higher in bedrock aquifers compared with overlying glacial aquifers.
3. The sandstone contains arsenic rich pyrite, which may be a source of the arsenic in the overlying glacial aquifer. Pyrite has not been identified in the glacial deposits.
4. May include a contribution of arsenic from underlying coal-bearing units. Arsenic-rich ground water may extend into the upper Kankakee River basin with Indiana, as suggested by high arsenic in surface water, sediment and biota (Fitzpatrick et al., 1998; Schmidt and Blanchard, 1997).
5. Arsenopyrite has been mentioned as a possible source of arsenic. However, high pH (the median pH of 11 samples with arsenic >50 µg/L is 8.25) and generally low sulfate concentrations (<25 µg/L; Ficklin et al., 1989) imply that sulfide mineral oxidation is limited, suggesting that the arsenic may be from Fe-oxide that was formed from the oxidation of arsenopyrite. The ground water with the highest arsenic concentration (15,000 µg/L) also had the highest pH (9.23).

Concentrations of Arsenic - Wells



Concentrations of Arsenic - Generalized



Arsenic in Texas

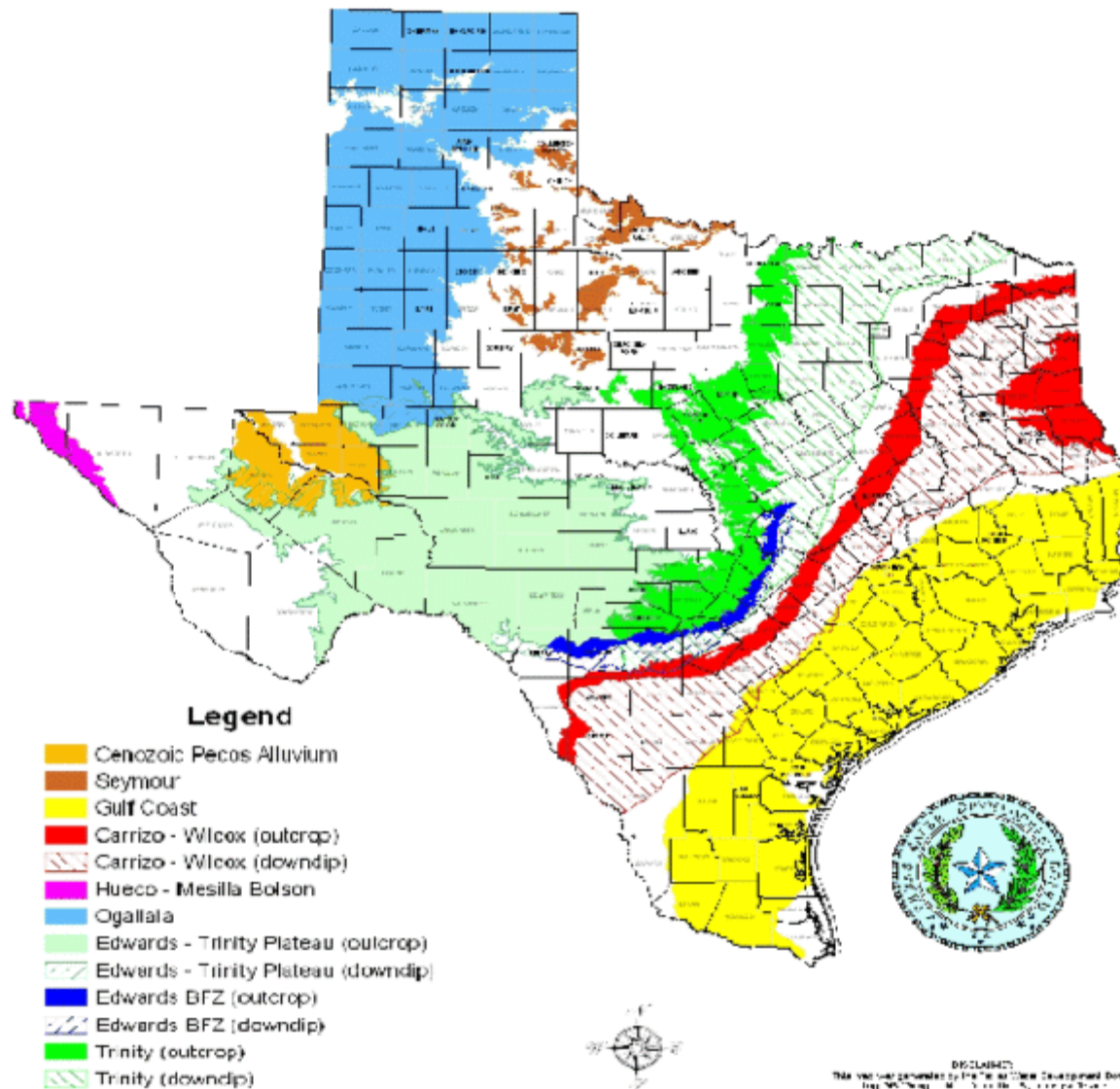
Ogallala Aquifer - Interbedded Sand, Clay, and Silt.

Gulf Coast Aquifer - Includes the Jasper, Chicot, and Evangeline Aquifers. Interbedded clays, sands, silts, and gravels.

- ▶ Processes - Arsenic in the ground water of the Ogallala has been found to be associated with natural uranium mineralization in the High Plains.
- ▶ Arsenic concentrations in some areas of the Ogallala and Gulf Coast aquifers are associated with agriculture.



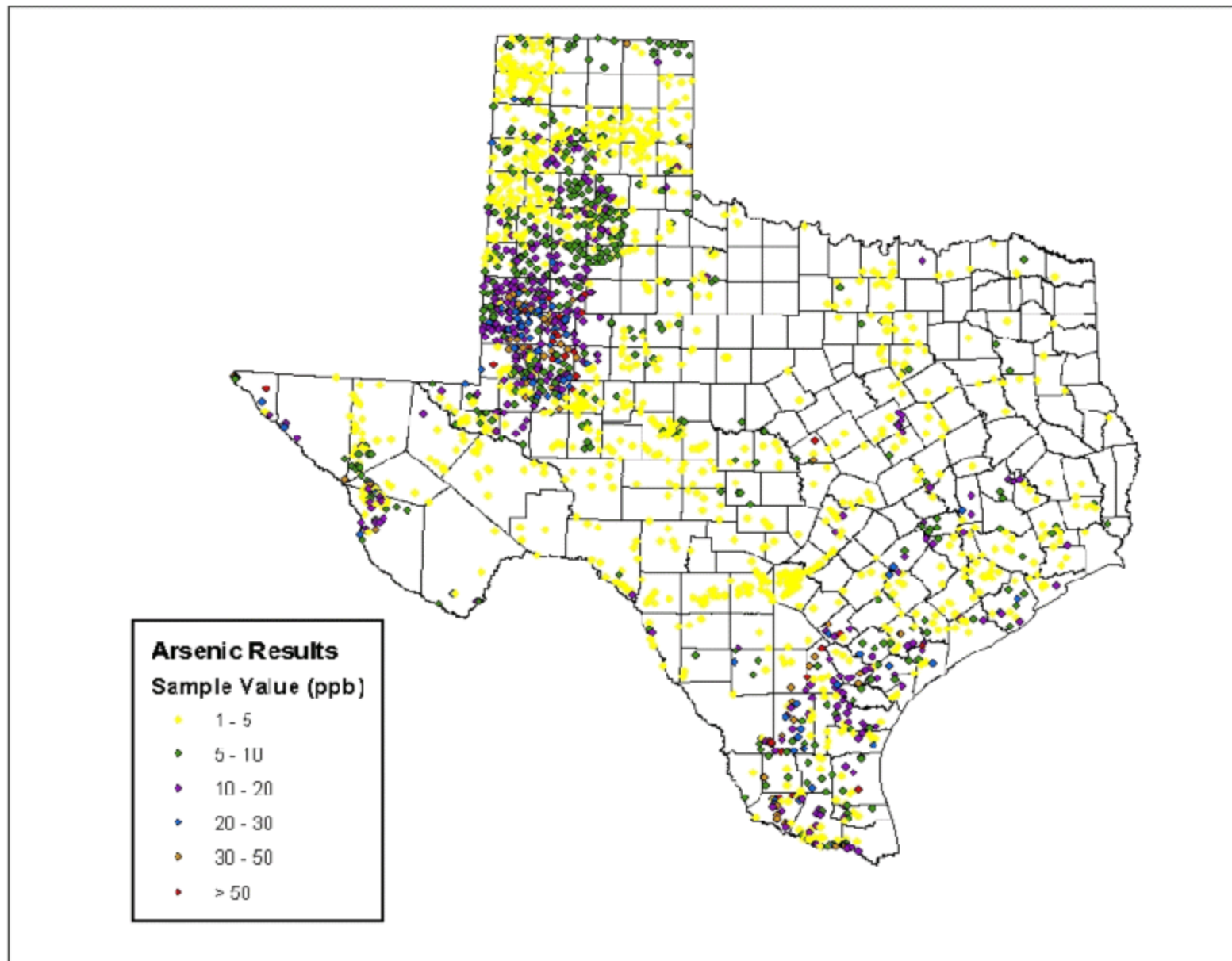
Major Aquifers of Texas



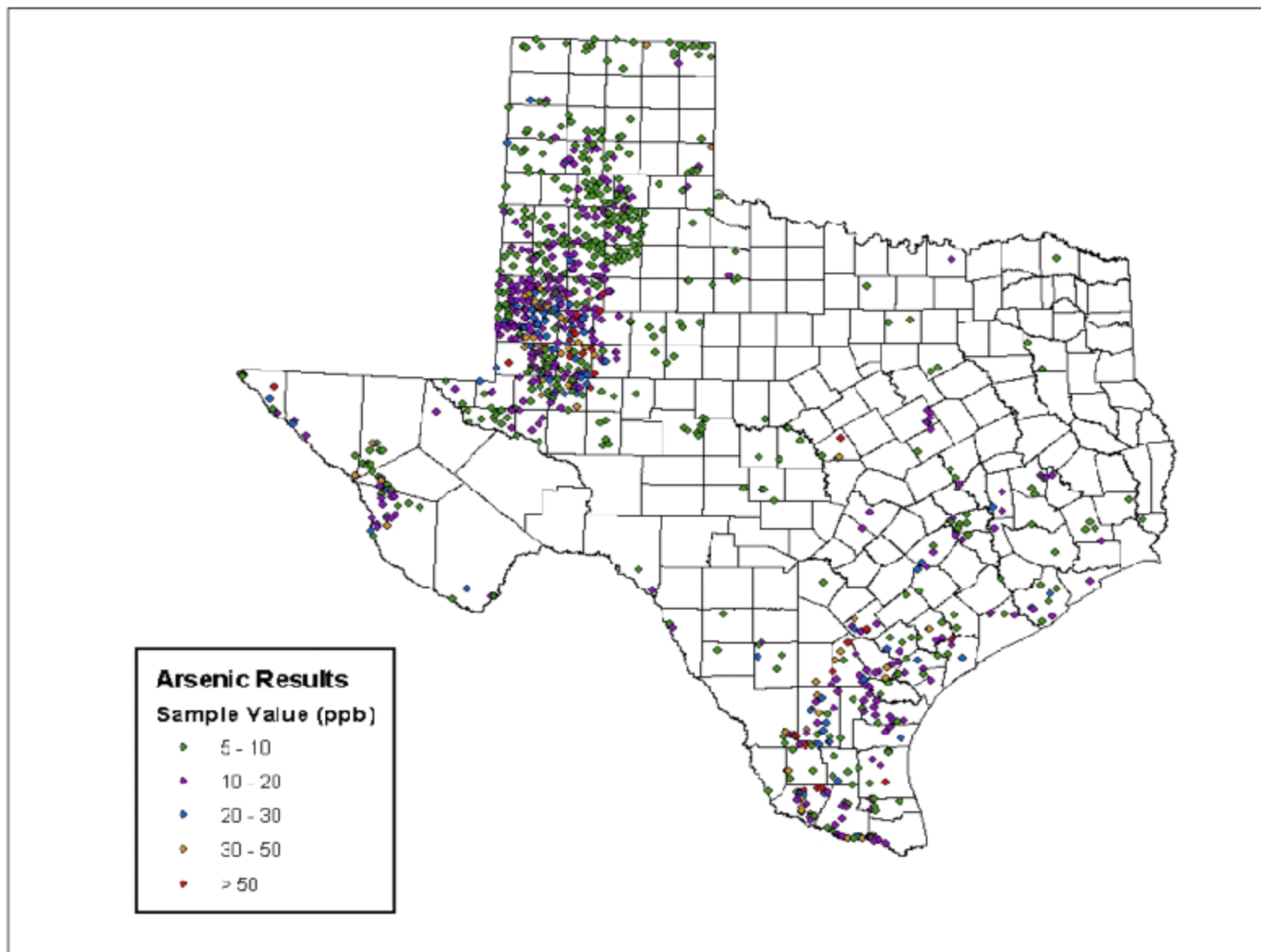
http://www.twdb.state.tx.us/mapping/maps/jpg/aqu_maj_8x11.jpg



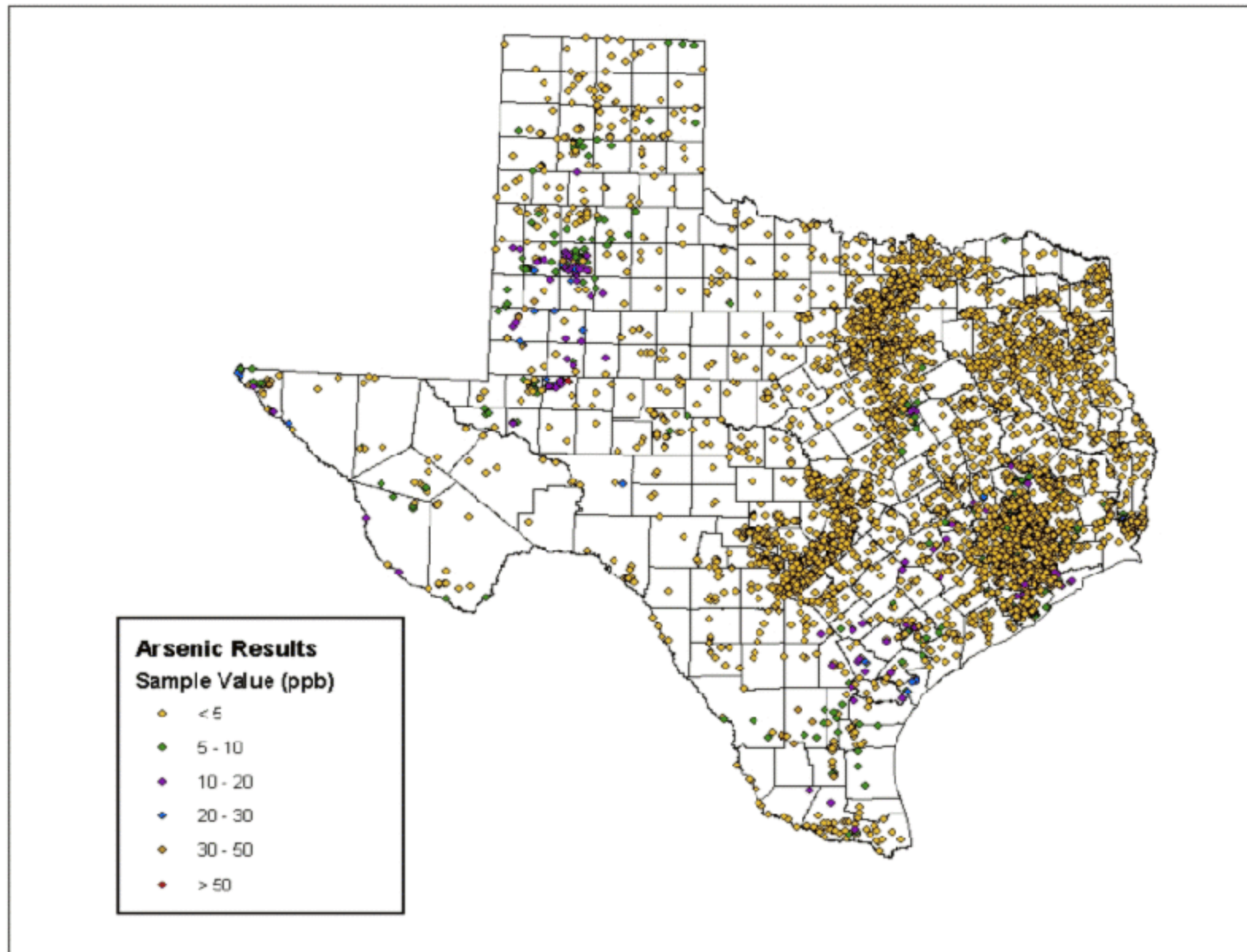
Arsenic Results - Texas Water Development Board (TWDB)



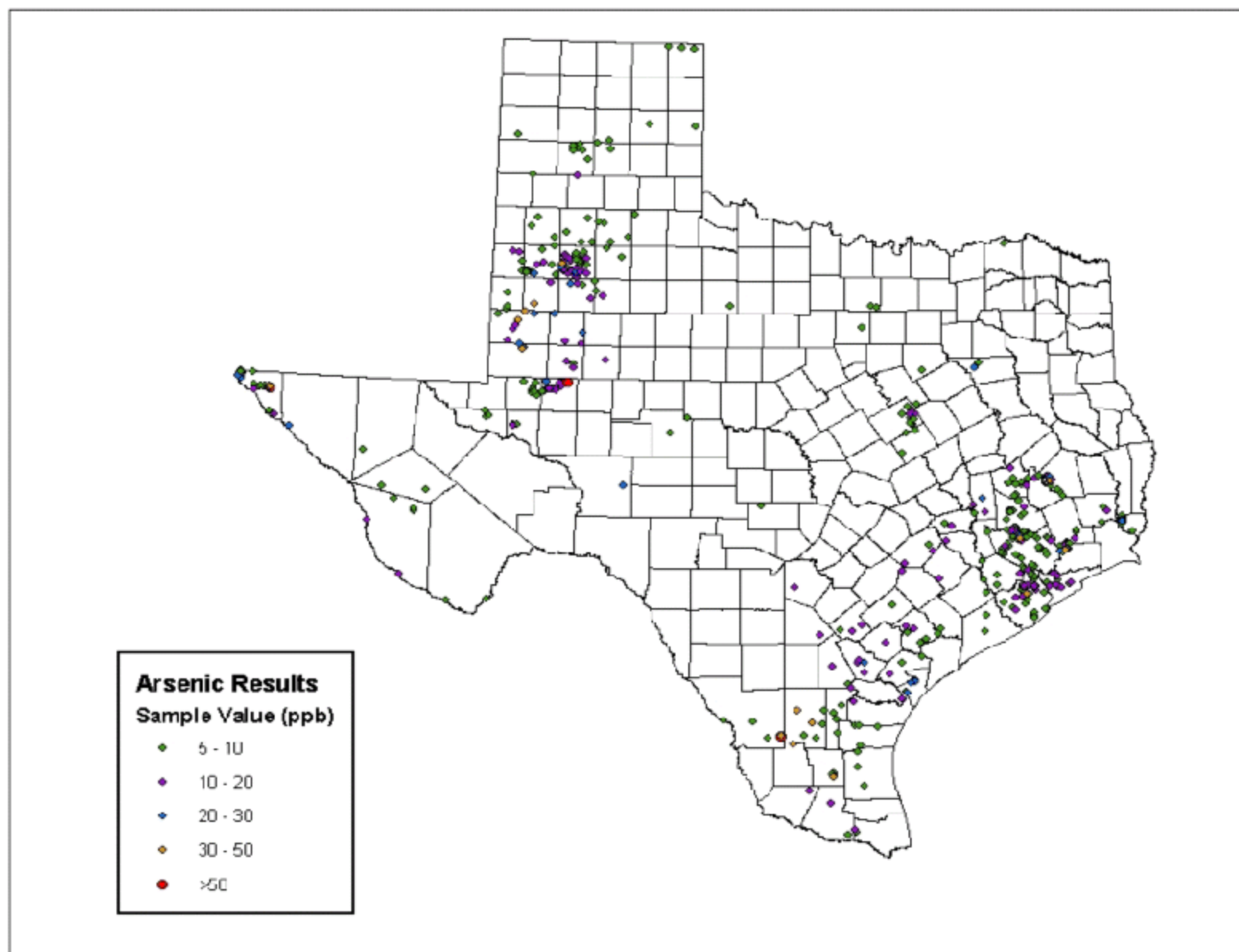
Arsenic Results - TWDB (excluding values < 5 ppb)



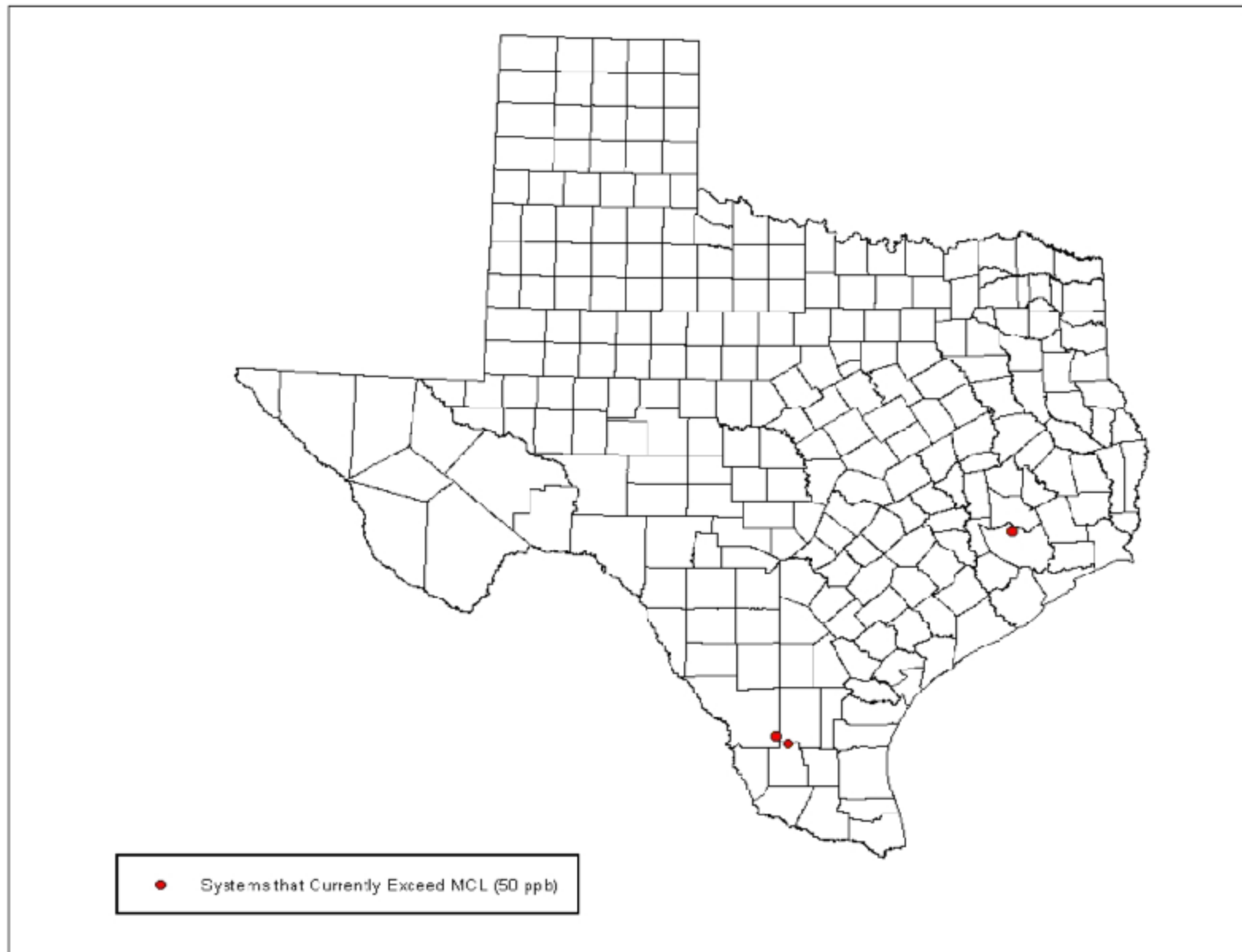
Arsenic Results - Public Water Systems (PWS)



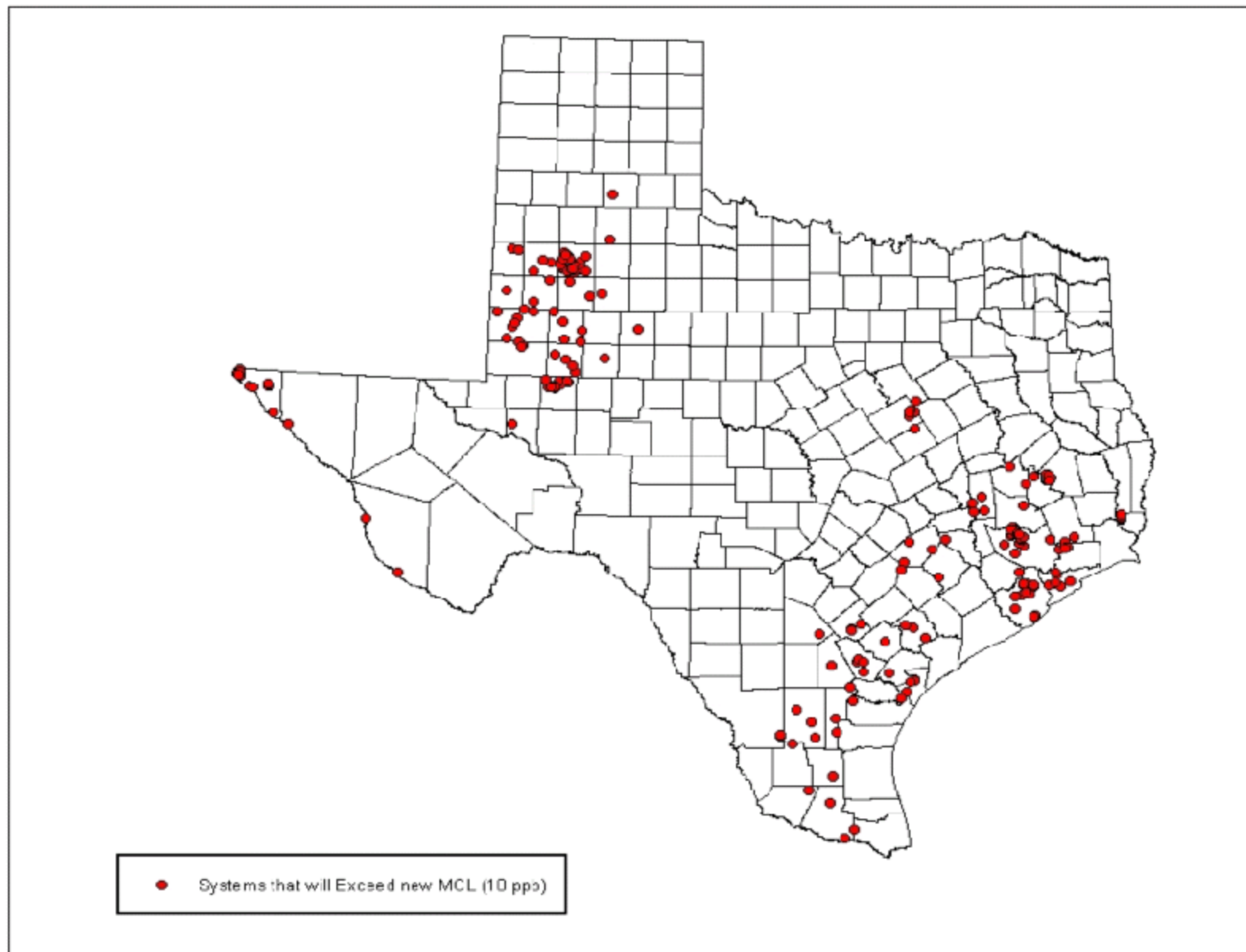
Arsenic Results - PWS - (excluding values < 5 ppb)



Public Water Systems that Currently Exceed the MCL (3)



Public Water Systems that will Exceed new MCL (234)



Arsenic Rule - Monitoring and Compliance

Kristine Krieg

Drinking Water Quality Program



Arsenic Rule

- ▶ The revised arsenic rule will take effect on January 23, 2006
- ▶ The arsenic maximum contaminant level (MCL) will be 0.010 mg/L (10 ppb)
- ▶ The rule applies to all community water systems and non-transient, non-community water systems
- ▶ Systems must sample at each entry point to the distribution system



Arsenic Rule (cont.)

- ▶ Ground water systems will be required to sample every three years
- ▶ Surface water systems will be required to sample annually
- ▶ After initial samples are taken and in compliance, systems will be eligible for reduced monitoring



Arsenic Monitoring

- ▶ Quarterly sampling must be implemented if the arsenic concentration in any sample is greater than the MCL
- ▶ Compliance is based on a running annual average of the quarterly samples

Texas Administrative Code §290.106(c)(3)(C)



Arsenic Monitoring

- ▶ After the initiation of quarterly sampling, a system may be returned to routine arsenic monitoring if quarterly sampling shows that the system is reliably and consistently below the arsenic MCL

Texas Administrative Code §290.106(c)(3)(C)



What happens to systems violating the Arsenic MCL?

- ▶ Must provide quarterly public notices to consumers as long as the violation exists
- ▶ Must seek alternative treatment methods or water sources to solve the problem



Public Notice Language

- ▶ This is not an emergency. However, some people who drink water containing arsenic in excess of the MCL over many years could experience skin damage or problems with their circulatory system, and may have an increased risk of getting cancer.
- ▶ You do not need to use an alternative water supply. However, if you have health concerns, you may want to talk to your doctor to get more information about how this may affect you.



Arsenic Mitigation

- ▶ Abandon problem source, seek alternative
- ▶ Blending to reduce levels below MCL
- ▶ Side stream treatment - treat a portion of the water then blend with untreated water to reduce levels below MCL
- ▶ Full treatment



Treatment

(Removal efficiency %)

- ▶ Sorption Treatment Processes
 - ! Ion Exchange (IX) (95 %)
 - ! Activated Alumina (AA) (95 %)
 - ! Iron Based Sorbents (IBS) (up to 98 %)
- ▶ Membrane Treatment Processes
 - ! Reverse Osmosis (RO) (>95 %)
(Most wasteful: 15-20% water loss)



Treatment (cont.)

(Removal efficiency %)

- ▶ Precipitation/Filtration Processes
 - ! Coagulation Assisted Microfiltration (90 %)
 - ! Enhanced Coagulation/Filtration
 - With Alum (<90 %)
 - With Ferric Chloride (95 %)
 - ! Enhanced Lime Softening (LS) (90 %)
 - ! Oxidation/Filtration - Greensand (50-90 %)



Cost to Consumers

Planning for the Future

- ▶ The EPA estimates that for systems <10,000 population, consumers may have to pay an additional \$38 - \$327 per year for water that meets the new standard
- ▶ For systems >10,000 consumers may have to pay an additional \$0.86 - \$32 per year.
- ▶ If your system will exceed the new standard, start planning now to spread out the cost over time



More Information

Guidance, training, treatment information

- ▶ <http://www.epa.gov/safewater/ars/implement.html>
- ▶ <http://www.usgs.gov>
- ▶ <http://www.twdb.state.tx.us>



Questions?



Drinking Water Quality
Program

(512)239-4691

Source Water
Assessment &
Protection Program

(512)239-4691

<http://www.tceq.state.tx.us>

